NISTIR 6890

Fire Resistance Determination and Performance Prediction Research Needs Workshop: Proceedings

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UCB — Fire Safety Engineering Science

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WORKSHOP

Research Needs for Fire Resistance Determination & Performance Prediction

National Institute of Standards and Technology
Gaithersburg, Maryland, USA

February 19 & 20, 2002

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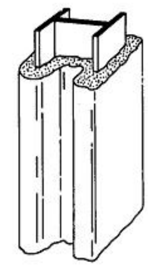
Overview

- Historical Background
- Fire Resistance
  - It's Origins
  - Focus on Building Elements
  - More Advanced Approaches
- Survey of "Fire Proofing" Materials
- Sprayed Fire-Resistive Materials
  - Performance Requirements
  - Tests for Cohesion &/or Adhesion
- Conclusions & Recommendations



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Background

Fires like the NYC Home Life Fire in 1898 helped shape the 20th century approach to "High Rise" fire safety.

The new approach was to make columns, walls, floors & other "elements" Fire Resistive.

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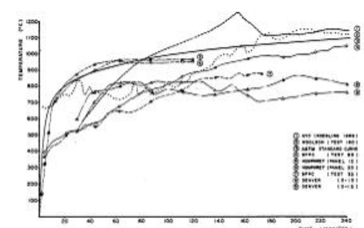
Fire Resistance & It's Origins

"Fire-Resistive Construction" is defined as "the ability of an element of building construction to withstand the effects of fire for a specified period of time without loss of its fire separating or load bearing function".

The standard ASTM E-119 Temperature v. Time curve evolved from many fire tests fuel was continually added to the fire. The Columbia University test hut is shown here.



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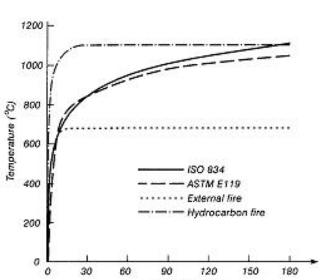
Fire Resistance in the Late 20th Century

Building elements, (columns, beams, walls, floors, etc) are exposed to the Standard Time v. Temperature Curve. They need to hold the load and/or prevent the fire from spreading to the next space. Here are 4 of the standard curves at the left. A column is ready for test at the right.



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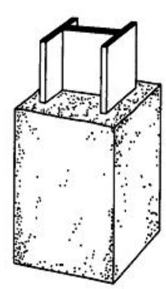
The First Materials Used for "Fire Proofing"

The 1st materials used in the early 20th century were traditional construction materials such as masonry or concrete.

These required substantial labor costs & high densities.



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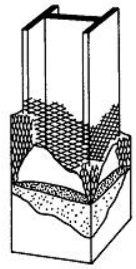
In the Middle Decades of the 20th Century Gypsum Plaster Came into Use

The first gypsum-based systems, such as the wire lath & plaster system at the right, also required substantial labor, & they were not very light.

They shared the basic protection mechanism with concrete of hydrated water.

This water of crystallization was immune from "drying out" & was very effective in achieving good fire performance.



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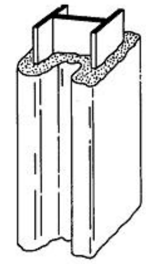
In the Last Half of the 20th Century "Sprayed Fire-Resistive Materials" Became Important

There was a general change from the traditional fire proofing systems to "Sprayed Fire-Resistive Materials" (SFRM) which used hydrated gypsum or portland cement as a binder with various fibers & other fillers.

These required lower labor costs & imposed weight penalties than the materials that had been previously used,



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Sprayed Fire-Resistive Materials

SFRM being applied to Soda Hall at UCB.

They have become the standard.

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Performance Requirements for SFRM

In 1972 Williamson gave 4 requirements for SFRM*:

A. Performance under actual fire conditions,

B. Durability & integrity under normal life of the structure,

C. Durability & integrity under the construction process, &

D. Integrity &/or general condition under special conditions such as earthquakes, thermo-nuclear attack, or the relative ease of repair following a fire exposure.

* Williamson, R.B., Report to Sprayon International, 1972.

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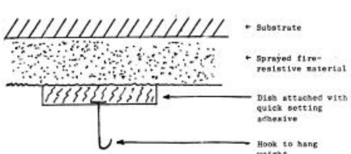
A Test for Cohesive/Adhesive Properties of SFRM



The test method schematically shown above is described in ASTM 736 which was originally published in 1980.

The fundamental problem with this test is that failure can occur in two ways as captured in the title: it is either a *cohesive* or an *adhesive* failure.

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Other Tests for SFRM

There are a number of tests currently used to evaluate the non-fire performance of SFPM:

ASTM E 605 Thickness & Density

ASTM 759 Effect of Deflection (of a deck)

ASTM 760 Effect of Impact on Bonding

ASTM 761 Compressive Strength

ASTM 937 Corrosion of Steel by SFRM

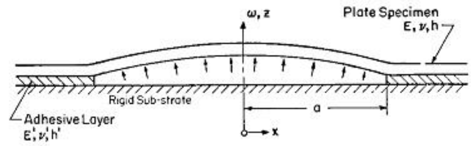
Like ASTM 736 These tests are not necessarily well linked to Materials Science.

Research Needs for SFRM

There are many different SFRM materials commercially available today, but the current test methods do not adequately address the most important properties or the range of conditions represented by the WTC attack.

For instance, the cohesive/adhesive test (ASTM 736) needs to be supplemented by a test which evaluates the bonding of the SFRM to the substrate.

A Possible Test for Adhesion of SFRM

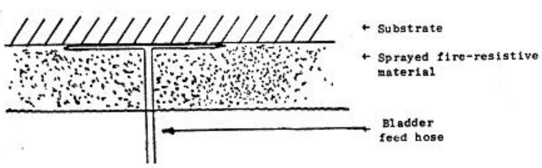


The schematic diagram above shows the geometry of the ***blister test*** to evaluate the adhesion of a deformable material adhered to a rigid substrate (Williams*).

There will always be an "adhesive layer" for any material, & it is important understand its structure.

*Williams, M.L., J. Appl Poly Sci, 14, (1970), p 735-745.

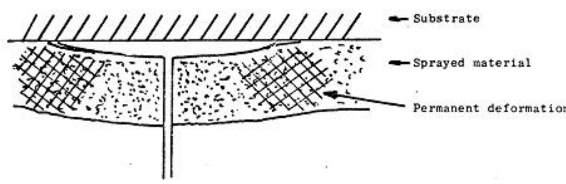
A Blister Test for SFRM



A thin plastic "bag" can be attached to the substrate before the SFRM is applied.

Then a measured pressure can be applied to the feed hose to cause the bag to inflate.

A Blister Test for SFRM



The application of pressure to the "blister" can cause the SFRM to deform &/or a crack to grow at the interfaced of the substrate & the SFRM.

A Blister Test for SFRM

The substrate on the left was oily & the SFRM had poor adherence

The SFRM was well bonded to the steel.

Conclusions & Recommendations

The fire and non-fire performance of Fire-Resistive Materials should be reevaluated in terms of the current challenges to buildings & other structures.

A new approach to testing & approval of these materials should be started.

There should be generalized "Materials Science-Based" research to characterize the available materials & to establish the "micro-structure/property" relationships that are central to Materials Science.